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ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA  
SYNTHESIS GUIDE FOR LINES OF COMMUNICATION.(U)  
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Synthesis guide for lines  
of communication

AD A104208

James Tazelaar

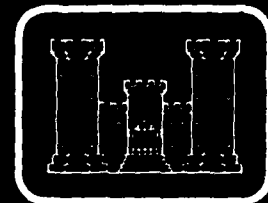
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report provides methods and procedures employed by U.S. Army Terrain Analysts to synthesize an LOC overlay from previously formatted military geographic information (MGI) thematic graphic data base (TGDB). Specific terrain factor overlays, such as Roads and Related Structures, Railroads, Airfields, etc. are taken one at a time and LOC-relevant data are traced onto a single frosted mylar overlay that, redrafted, becomes the final LOC document. By combining specific terrain factor overlay data from →		

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## PREFACE

This guide for Lines of Communication (LOC) is one of a series of Analysis and Synthesis Guides to be produced. After some modifications, the guides will be published as Department of Army manuals. For this reason, critical comments and suggestions are requested by the author.

The published guides in this series are

<u>Number</u>	<u>Authors</u>	<u>Title</u>	<u>AD Number</u>
ETL-0178	Jeffrey A. Messmore Theodore C. Vogel Alexander R. Person	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR VEGETATION (Report No. 1 in the ETL Series on Guides for Army Terrain Analysts)	AD-A068 715
ETL-0205	Theodore C. Vogel	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR ROADS AND RELATED STRUCTURES (Report No. 2...)	AD-A080 021
ETL-0207	James Tazelaar	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR GEOLOGY (Report No. 3...)	AD-A080 064
ETL-0220	Alexander R. Pearson Janet S. Wright	SYNTHESIS GUIDE FOR CROSS-COUNTRY MOVEMENT (Report No. 4...)	AD-A084 007
ETL-0247	Roland J. Frodigh	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR CLIMATE (Report No. 5...)	AD-A095 158
ETL-0254	Janes S. Wright Theodore C. Vogel Alexander R. Pearson Jeffrey A. Messmore	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR SOIL (Report No. 6...)	

This study was conducted under DA Project 4A762707A855, Task C, Work Unit 11, "Military Geographic Analysis Technology."

This study was done under the supervision of A.C. Elser, Chief, MGI Data Processing and Products Division; and K.T. Yoritomo, Director, Geographic Sciences Laboratory.

COL Daniel L. Lycan, CE was the Commander and Director and Mr. Robert P. Macchia was Technical Director of the Engineer Topographic Laboratories during this report preparation.

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U.S. Customary Units of Measurement used in this report can be converted to metric (SI) as follows:

Multiply	BY	To Obtain
inches	25.4	millimeter
feet	30.48	centimeter
miles	0.6093	kilometer
acres	0.405	hectare
ounces	28.57	gram
gallons	3.785	liter
Fahrenheit degrees*	5/9	Celsius degrees, Kelvin

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\*To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula:

$$C = (5/9) (F-32)$$

To obtain Kelvin (K) readings, use formula:

$$K = (5/9) (F-32) + 273.15$$

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## Synthesis Guide for Lines of Communication

### 1. INTRODUCTION

The capability to relocate manpower and materiel in an operational area is an essential ingredient of combat power and is often decisive to the outcome of a battle. Transportation is dependent on adequate lines of communication (LOC) within a combat zone, and transportation plans are dependent upon accurate intelligence concerning lines of communication. As a result, some form of LOC product or complex factor map overlay depicting this intelligence is necessary.

Lines of communication products enable commanders to judge the types, density, and distribution of mostly manmade elements of transportation. These elements include roads and related structures, airfields, and railroads. Table I lists the major elements that should be considered by a terrain analyst preparing an LOC product.\* The lines of communication (LOC) product shows the spatial relationships of these elements, together with available information for each element, in a format calculated to assist military tacticians concerned with movement of men and materiel. This combining of LOC-relevant elements and their reproduction in a graphic form is termed "synthesizing." The LOC product is, then, a synthesis of previously analyzed terrain data. Figure 1 is an illustration of a sample LOC product that has been annotated to show a typical analyst's data worksheet obtained by synthesizing selected information from a military geographic information (MGI) thematic graphic data base (TGDB). The symbols for several LOC data fields are annotated to show an analyst's worksheet of data obtained by synthesizing selected information from the MGI TGDB. When the data is considerable, supplementary information is also recorded in the LOC Data Tables (see figure 2).

The synthesis process means taking specific factor overlays out of the military geographic information (MGI) Thematic Graphics Data Base (TGDB), placing a sheet of frosted mylar on the individual terrain factor overlays one at a time, and tracing only the LOC-pertinent data elements onto the single sheet of mylar. This sheet of mylar (rough copy), termed the "Complex Overlay," becomes the base from which the LOC product will be made. Often this overlay is the final LOC document that is submitted

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\*Because of their complexity and because a terrain analysis procedural guide has not been completed, ports, harbors and inland waterways are not considered in this synthesis guide for lines of communication (LOC).

Table 1. MAJOR DATA ELEMENTS FOR LOC PRODUCTS

<u>ROADS</u>		<u>**FORDS</u>	<u>AIRFIELDS</u>
Identification Number	Length		Identification
Category (Highways, Routes, Autobahns, etc.)	Width		*Runway orientation
Segments	Depth		Type
*Type	Bottom Conditions		*Surface Material
*Width	Approaches		Parking Facilities
Surface Materials & Conditions		<u>**FERRIES</u>	Hangars
Shoulders			POL
Medians			Ammo/Bomb Storage
Obstacles	Crossing Length		Quarters
Culverts	Vessel Characteristics		*Elevation
Cuts and Fills	Approaches		*Length/width
Turn-outs, Emergency Drive-offs	Load Class		
& Parking Areas		<u>*TUNNELS, GALLERIES &amp; SNOWSHEDS</u>	<u>RAILROADS</u>
Level Crossings			*Electrified
*Constrictions	*Length and Width		*Abandoned
*Grades	Construction Details		Routes
*Sharp curves	Overburden		*Yards/Terminals
*Roads or Bridge under construction	*Clearances		Rolling Stock
			Junctions/Crossings
			*Track(s)
			*Gauge(s)
			Bridges
<u>BRIDGES &amp; OVERPASSES</u>			
*Length			
*Width			
*Load Class			
Construction Type			
*Clearances			
*Bypass Potential			
*Data elements deemed essential for LOC synthesis **Names and locations only Note; Elements in columns 1 and 2 are on the Roads and related features factor overlay			



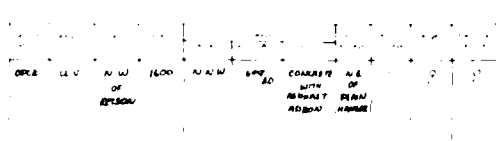
## LOC ROADS

1	2	3	4	5	6	7		8		9		10		11
ROAD NO	SEG NO	SEGMENT UTM	NO CUL	SURF MATL	COND	WIDTH (M) TRAVELED WAY		MEDIAN		SHOULDERS		OBSTACLES		CROSS SECTION OR COMMENT
						a.	b.	WIDTH (M)	MATL	WIDTH (M)	MATL	UTM	TYPE	
Ma	1	146780	3	pb	good	7.0		N A		2.0	gravel	124692	Stone wall	
State	2	351234	6	pb	good	6.0		N A		2.5	gravel	162921	Bridge	
223	3	523611	2	rb	good	6.0		N A		2.0	gravel	267982	Rock cut	

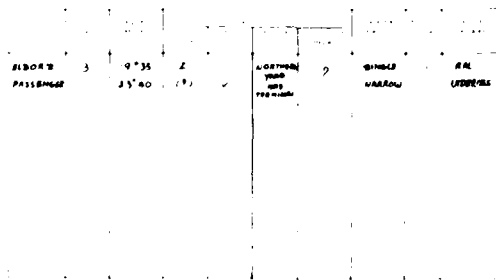
## LOC BRIDGES

1	2	3	4	5				6	7	8				9	10	11		
ROAD NO	SEG NO	BRIDGE NO	BRIDGE UTM	LOAD CLASS				NO SPANS	TOTAL LENGTH (m)	SPAN CHARACTERISTICS				FEATURE CROSSED	BYPASS COND	SKETCH OR COMMENT		
				WHEEL		TRACK				CON. MATL	CONST TYPE	ROAD WIDTH	OH CLEAR				UB CLEAR	
				→	←	→	←			a	b	c	d	e				
Va State	5	1	592114	105	40	65	25	2	124	MC	Slab	7.0m	unlimited	10m	wind river	?	1M 3.5M 3.5M 1M	①
123	6	2	131695	85	30	40	20	1	83	CS	Beam	6.5m	unlimited	9.5m	difficult railroad route 223	(Steep embankment)	600' 10M	Vertical Clearance Unlimited

## LOC AIRFIELDS



## LOC RAILROADS



### Figure 2. Sample LOC Data Tables

These Data Tables are typical of the format used as supporting materials to accompany LOC maps. Often, however, the terrain analyst may opt to confine the data to symbols and eliminate Data Tables where the information is limited.

for a quick response LOC product. In Figure 3 the basic steps are shown in the synthesis of factor overlay information to produce an LOC map product.

This synthesis guide shows methods of combining specific terrain factor overlays from an existing MGI TCDB and their pertinent details (data tables) to produce an LOC product suitable for expedient reproduction by Army field elements. The development of terrain factor overlays is the subject of separate ETL procedural guides and is not treated here. This synthesis guide presupposes the existence of the requisite factor overlays and related tables needed to prepare the LOC product.

This synthesis guide provides terrain analysts with methods and procedures required to synthesize a Lines of Communication (LOC) product and is organized as follows:

Section II identifies and describes available SOURCE MATERIALS such as Terrain Factor Overlays, Maps, Aerial and Ground Photography and Literature. This is followed by a PROCEDURAL OUTLINE that provides an introductory overview of the major steps required to perform an LOC synthesis. The next section, SYNTHESIS PROCEDURES, presents a more detailed step-by-step methodology in preparing an LOC product, utilizing available source materials and how to update and check this material if necessary. Proposed Simplified LOC Symbols are provided in Appendix A. Appendix B provides useful guidelines to assist terrain analysts in preparing terrain factor overlays for airfield and railroad analysis. Appendix C provides LOC related data on FOREIGN MAPS and Appendix D provides SUPPLEMENTARY REFERENCES that should be useful for terrain analysts.

## II. SOURCE MATERIALS

A. Terrain Factor Overlays. The primary source material used in the synthesis effort are the terrain factor overlays and data tables from the MGI Thematic Graphic Data Base (TGDB). The terrain factor overlays and data tables portray the terrain and/or environmental factors (roads and related structures, railroads, airfields, climate, etc.) that affect military planning and operations in a given geographic area. The essential physical properties of these terrain and/or environmental factors, including known engineering characteristics, and their spatial distribution in an area are shown in graphic (overlay) format. In some instances, the analyst may have to update certain TGDB overlays before using them. This is done by interpreting recent aerial photos, maps, and to a limited extent, literature.

B. Maps. The terrain analyst should examine available maps to become familiar with the distribution of the major data elements in the area of interest. In addition, the analyst may discover that this material requires updating to reflect changes in the environment, both

natural and manmade, that affect LOC.

C. Aerial and Ground Photography. Reconnaissance photography, including vertical and oblique aerial photographs, is an excellent source of updating information, particularly when ground access is denied or map sources are known to be out of date. Both vertical and oblique aerial photography acquired in a manner that permits stereo or three-dimensional viewing will enable the analyst to obtain fairly accurate physical measurements of important features contained in the road, airfield, and railroad data fields.

D. Literature. Literature sources include all reconnaissance reports, engineering reports, "as-built" drawings, engineering drawings of LOC-pertinent elements, and any written material that provides useful information. Normally, these materials are maintained by state, county, or city governments and are stored locally.

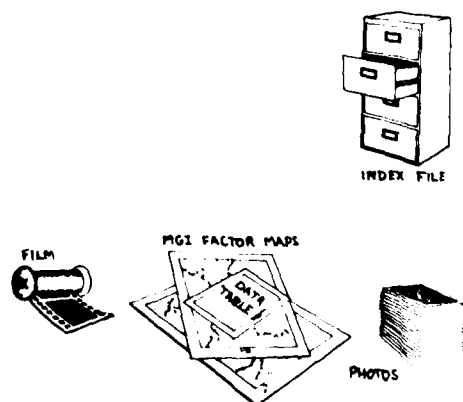
Before proceeding further, the analyst involved in the synthesis of LOC overlays should examine the training manuals, field manuals, and the texts listed in Appendix D. In theory, the analyst's work will have produced the TGDB factor overlays from which synthesis derives one or more LOC overlays. In practice, however, the analyst may find a sudden need to expedite the updating of a part of the source materials. Familiarity with the reference materials will be of great help.

### III. PROCEDURAL OUTLINE

A. LOC Synthesis Outline. This section provides an introductory overview of the steps required to perform an LOC synthesis of the various terrain factor overlays and data tables available from the MGI TGDB. The terrain data chosen to illustrate the procedure are Roads and Related Structures, and Railroads. The simplicity of the synthesis effort is illustrated below.

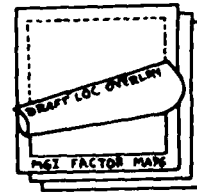
1. Review MGI Thematic Graphics Data Base (TGDB).
2. Evaluate and select sources.

#### PROCEDURAL OUTLINE





3. Extract pertinent data.
4. Draft LOC overlay.



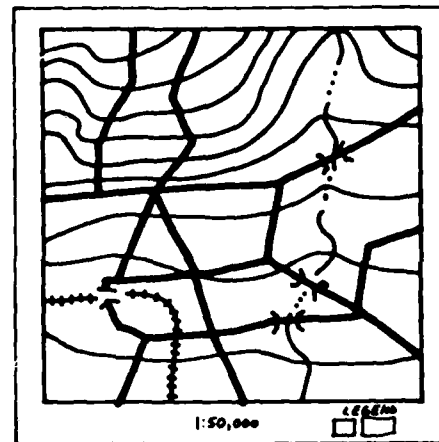
Although for clarity several steps are shown in the diagram, it is often more practical to combine steps where conditions permit. For instance, if the amount of LOC-pertinent data transferred to the draft LOC overlay is not great, i.e. the overlay is not cluttered, then the draft can be cleaned up and submitted for reproduction as the final LOC product.

A technical guide has been published by ETL describing the analysis procedures by which terrain data base factor overlays are produced for the Roads and Related Structures.\* Because comparable reports for Railroads and Airfields are not available, Appendix B of this report provides useful guide lines to assist terrain analysts to handle the analysis of these data fields in addition to objectives and design elements common to all factor overlays. A general overview of the steps required to prepare an LOC product involving, Roads, Bridges/Overpasses, and Railroads are described and illustrated in the following pages.

#### B. LOC Synthesis for Roads

1. Study the requirements from Corps/Division prior to preparing specifications for synthesizing the LOC roads.

2. Examine the base topographic map to become familiar with the LOC study area road net.



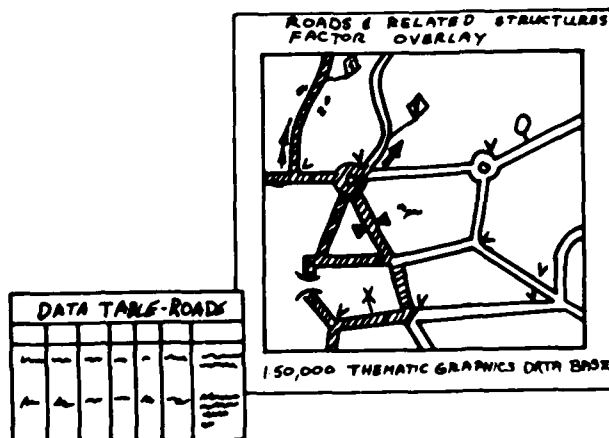

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\*Terrain Analysis Procedural Guide for Roads and Related Structures, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, ETL 0205, October 1979, AD-A 080 021

3. Examine the MGI TGDB Roads and Related Structures factor overlay(s) to select the major and secondary roads for the LOC study.

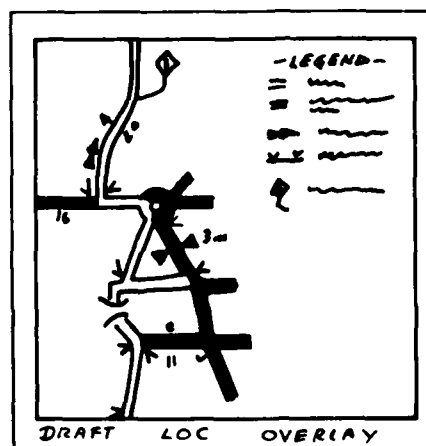
4. Identify major road categories to be used in the LOC study, e.g. All-Weather, Hard Surface, Fair Weather, Loose Surface.

5. Examine the MGI Roads Data Table(s) to select the essential data elements listed in table 1 of this guide.

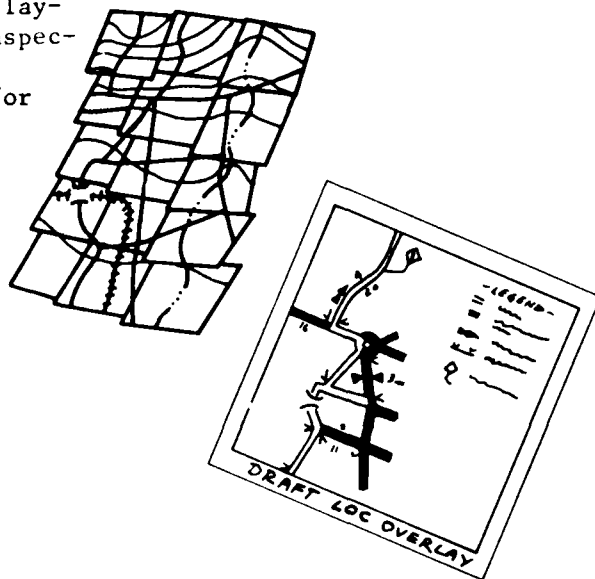


6. Overlay the MGI TGDB Roads and Related Structures factor overlay with a clean overlay. Draft onto the clean overlay the selected major and secondary roads. Draft appropriate roads symbols onto overlay, using data elements from data base data table(s).

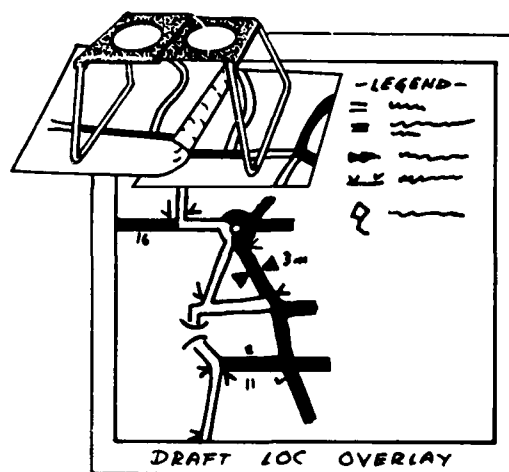
7. The initial LOC Roads overlay is now in draft form. Obtain aerial photos for the area of interest to verify and update the LOC Roads information shown on the overlay draft.



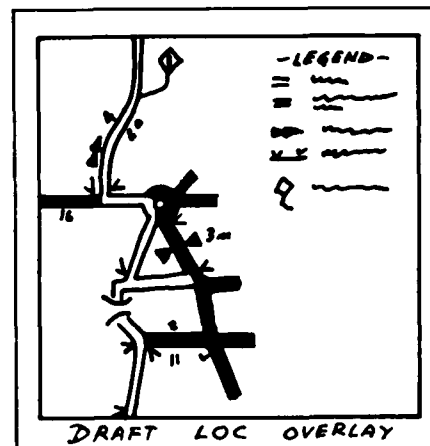
8. Prepare an informal lay-up from alternate photos. By inspection, examine the roads network, correlating the roads selected for the LOC study with the photos.



9. Examine stereoscopically the selected roads to ascertain any road changes or errors in the data base parameter information. Revise and record any changes onto the draft overlay.



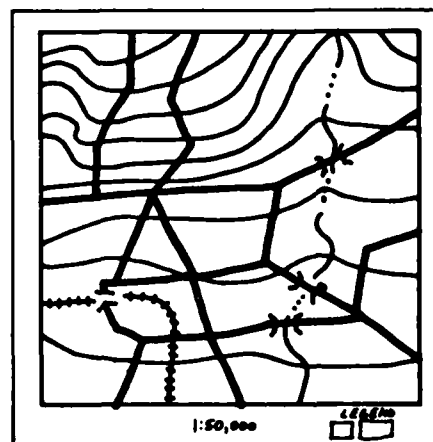
10. Check LOC Roads draft overlay to insure the selected roads meet the user's request. Clean up the overlay, and recheck road symbols and legend.



### C. LOC Synthesis for Bridges/Overpasses

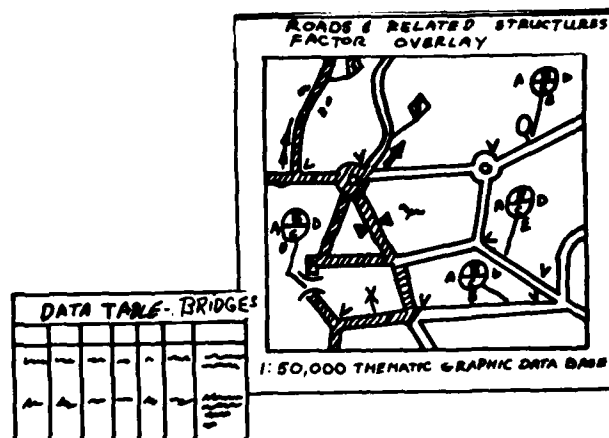
1. Study the requirements from Corps/Division prior to preparing specifications for synthesizing the LOC - Bridges/Overpasses.

2. Examine the base topographic map to become familiar with the LOC study area bridges (shown by symbols).



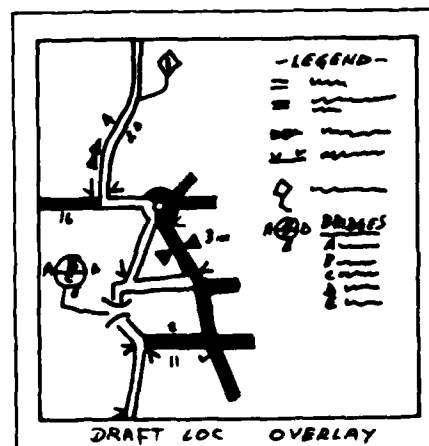
3. Examine the MGI TGDB Roads and Related Structures factor overlay(s). Select all LOC-relevant bridges/overpasses.

4. Examine the MGI TGDB Bridges Table(s) to select the data elements listed in table 1 of this report for each LOC-relevant bridge/overpass.

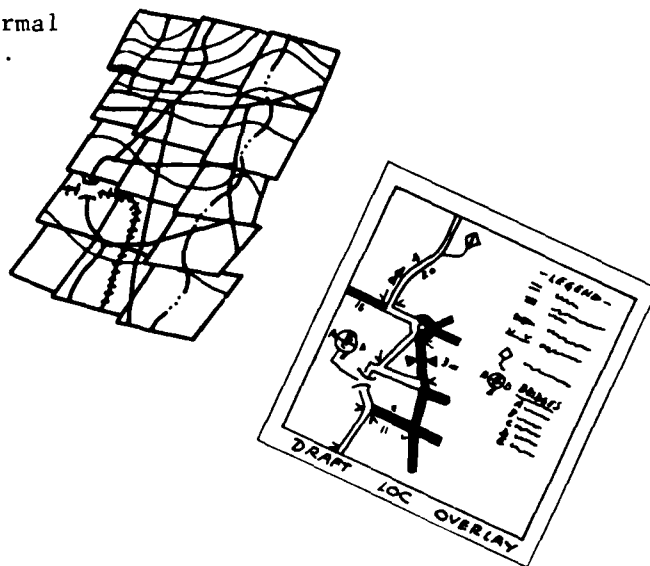


5. Overlay the MGI TGDB Roads and Related Structures factor overlay with the LOC overlay. Draft onto the LOC overlay the selected bridges location(s). Draft the Bridge symbols onto the LOC overlay using the data elements from data base table(s).

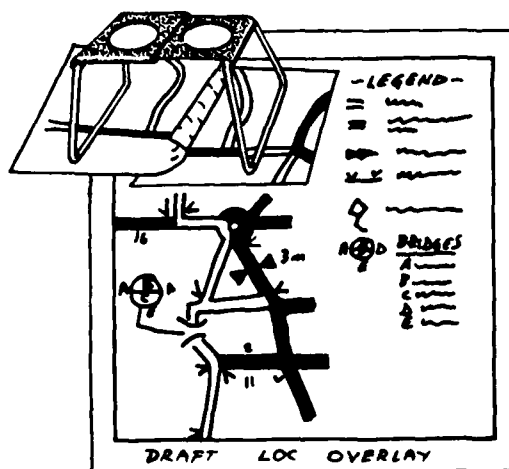
6. The initial LOC Bridge overlay is in draft form. Return the MGI materials to files. Obtain aerial photos to update the Data Base Bridges shown on the overlay draft, if relevant.



7. Prepare an informal layup from alternate photos. By inspection, examine the roads network. Locate the Bridge(s) selected for the LOC study area.

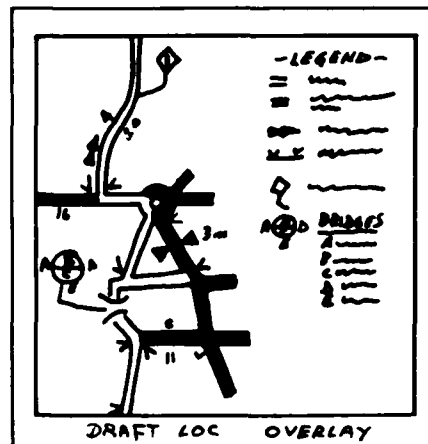


8. Examine stereoscopically the selected Bridge(s) to ascertain any changes or errors in the data base parameter information. Revise and record any changes on draft overlay.



9. Check LOC Bridge draft overlay to insure the selected Bridge(s) meet the user's request.\* Clean up the overlay, and recheck all symbols and legend.

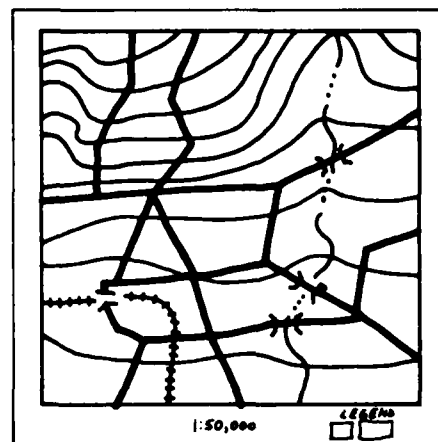
\*Bridge  $\geq$  18 m must be shown.



#### D. LOC Synthesis for Railroads

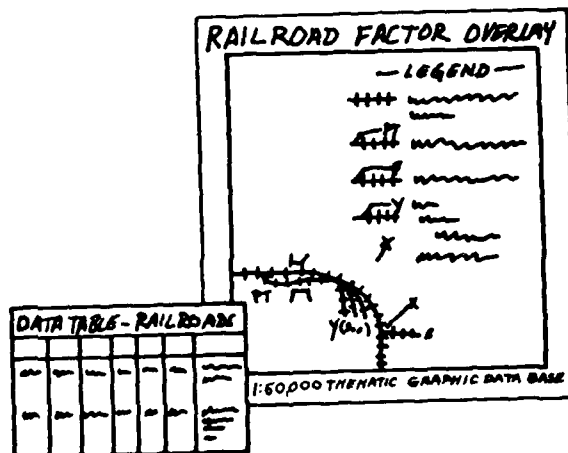
1. Study requirements from Corps/Division prior to preparing specifications for synthesizing the LOC - Railroads.

2. Examine the base topographic map to become familiar with the LOC study area railroads.



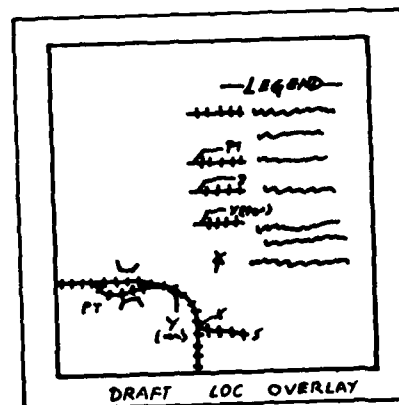
3. Examine the MGI TGDB factor overlay(s) to select the railroads most pertinent to the LOC area of interest.

4. Examine the MGI TGDB Railroads Data Table to select the essential data element information as listed in table 1 of this report.



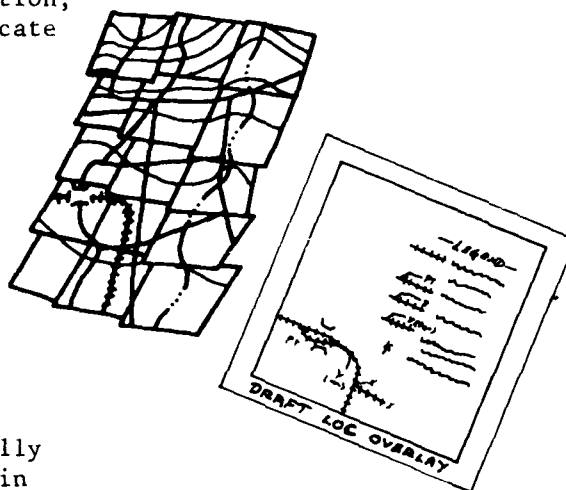
5. Overlay the MGI TGDB Railroads factor overlay with the LOC overlay. Draft onto this the selected railroad data. Draft the Railroad symbols onto the LOC overlay using the data elements in the Data Base table(s).

6. The initial LOC Railroads overlay is in draft form. Return the MGI materials to files. Obtain aerial photos to update, if necessary, the data base Railroad data on the LOC draft.

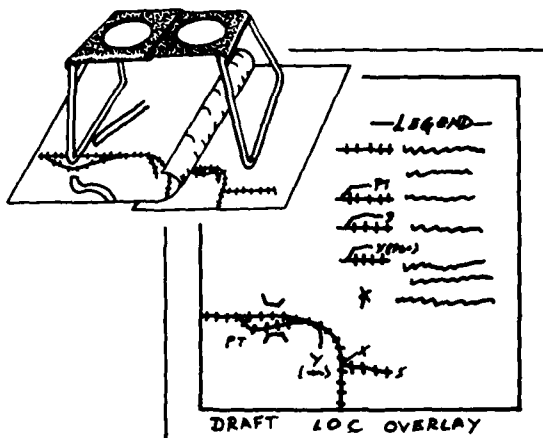




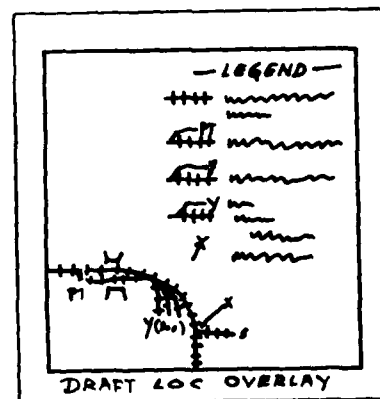
7. Prepare an informal layup from alternate photos. By inspection, examine the area's Railroads. Locate the segments selected for the LOC study area.



8. Examine stereoscopically the selected Railroads to ascertain any changes or errors in the data base parameter information. Revise and record any changes on draft overlay.

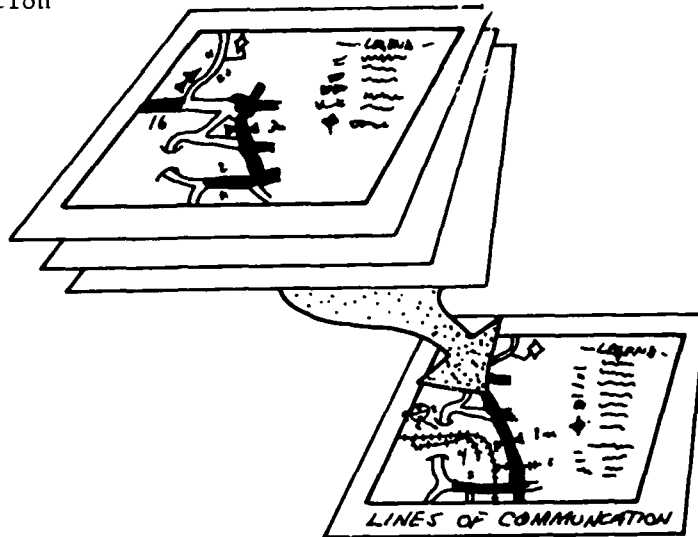


9. Clean up the draft LOC Railroads overlay. Recheck all symbols and legend.



#### E. LOC Synthesis - Final Manuscript

Here, for illustration purposes, the individual data elements are shown as separate overlays. In LOC practice, these are commonly drafted onto a single overlay. This draft overlay, which is cleaned up, constitutes the final LOC manuscript.



This draft LOC manuscript is ready for reproduction by army field units, or can be forwarded to meet the requestor's need for LOC in a specific area.

For illustrative purposes an abbreviated example has been shown. More commonly, the number of Bridges in many areas can require preparing separate LOC Bridge Data Tables. These are then identified by a numbered symbol (See Appendix A) with reference to the tables. If the number is such that they can be depicted by symbol on the LOC overlay, this is recommended.

Additional LOC related terrain data for Airfields and Railroads, etc. are synthesized in the same manner as has been presented in this section for Roads and Related Structures.

#### IV. SYNTHESIS PROCEDURES

This section presents in greater technical detail the step-by-step methodology of terrain synthesis to produce a final LOC manuscript suited for reproduction.

In figure 3, steps are shown to be followed in the synthesis of information from existing Factor Overlays and Data Tables. In the synthesis process, the analyst should review map areas and map legends and examine available aerial photography, if time and conditions permit. This review provides the analyst with (1) a needed visual familiarity with the area that examination of the MGI TGDB overlays alone cannot produce, and (2) a chance to discover areas that may need data updating.

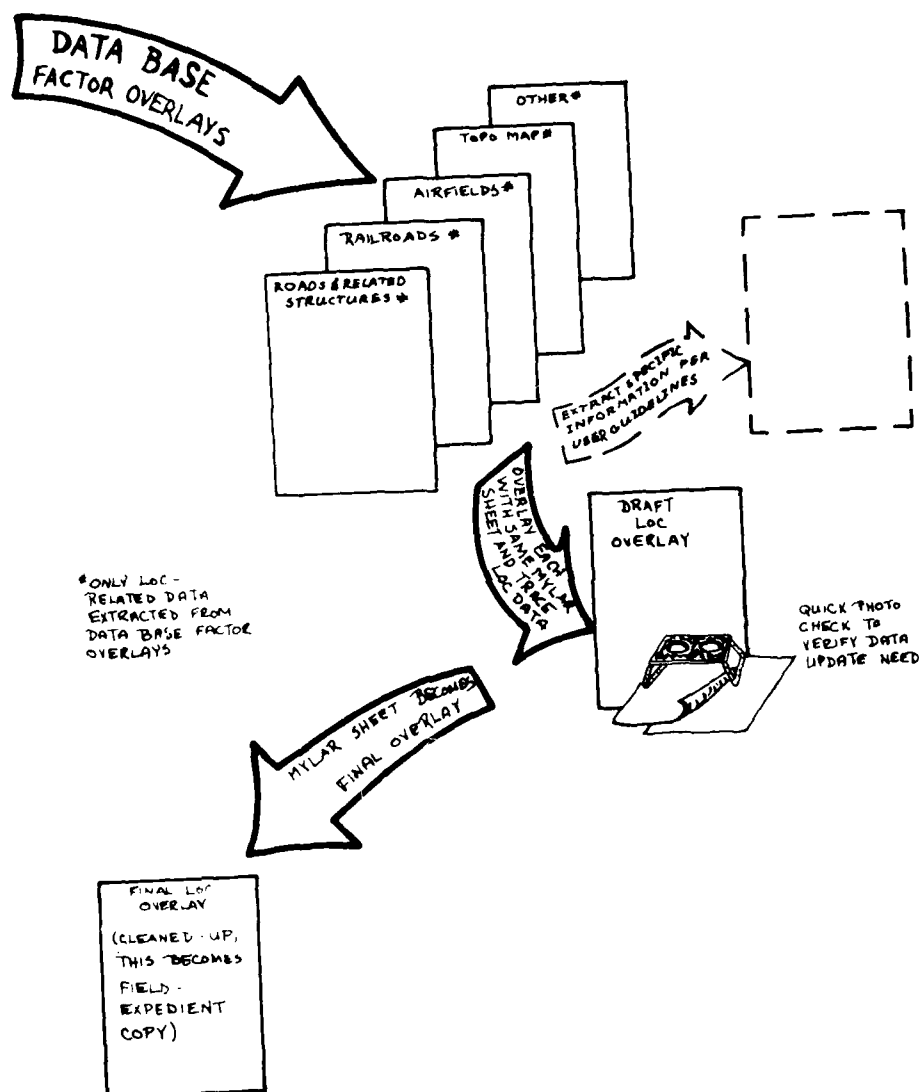


Figure 3. LOC Synthesis Process

In table 1, the major data elements are listed that are used in synthesis and preparation of LOC overlays and, where necessary, LOC Data Tables. Certain of these data elements, indicated by asterisks, are essential in preparing useful LOC studies.

By superimposing an initially blank sheet of mylar over the MGI TGDB overlays, e.g. Roads and Related Structures, and by examining the overlay symbols, the analyst selects those aspects that are useful to the presentation.

Generally, each data base overlay has more data than is needed for a given study. The analyst then must "select-out" only that information deemed most needed to meet the requirements for a product (see figure 4).

In the following discussion, only those discrete bits of information (per data field) that are thought essential to an adequate LOC synthesis are presented. This distillation of data, available on the data base factor overlays and accompanying data tables, is essentially a simplification of the total data produced during the analysis phase.

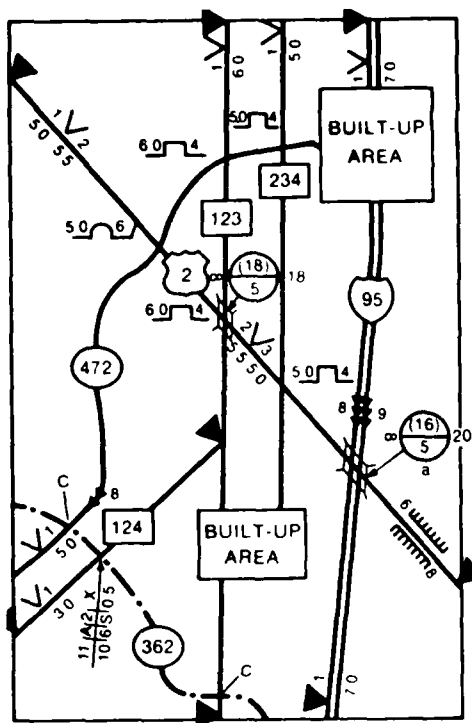
The following paragraphs describe in detail synthesis and photo analysis procedures required to prepare an LOC manuscript consisting of Roads, Bridges/Overpasses, Fording Sites, Ferry Sites, Tunnels, Galleries, and Snowsheds.

#### A. LOC Synthesis Procedure for Roads

Obtain the base map (usually, 1:50,000 scale) and the Roads and Related Structures Factor Overlay from the data base. Register a clean overlay to the MGI TGDB overlay. By pencil, delineate all built-up areas and all major transportation routes. The data base factor overlay legend will usually identify three broad route categories, all-weather hard surface, all-weather loose surface, fair-weather loose surface. Variations of these categories can occur. The terrain analyst then must decide how to correlate the differing categories with the preceding three preferred for LOC synthesis work.

The data base material will show all routes within the map area. For LOC synthesis, however, the analyst must select only the Roads data deemed pertinent to the requested study. If no guidelines have been given for the initial LOC draft, select only the routes shown as "All-Weather" on the Roads and Related Structure factor overlay. If the request calls for both "primary and secondary roads, hard surface only," the terrain analyst selects only the routes meeting the hard surface category.

The analyst should know whether the requested study is, or can be, confined to only a portion of the map area, e.g. LOC between Points A and B. In any area having a dense transportation network, eliminating unnecessary route data simplifies the work and produces a more readable LOC product.



Typical Roads and Related Structures found on an MGI TCDB overlay (left). The data shown was derived from an analysis of maps, literature, and photos. The details for the data elements are recorded on a Roads factor overlay data table (not shown here). This shows more than is needed for a hypothetical LOC study. After examining the map area and identifying the LOC-relevant data elements, the analyst checks available aerial photography of the area.

The overlay (right) represents a typical LOC Roads overlay. It shows only those Road elements deemed by the analyst to be important with respect to the request for an LOC of the region around the two built-up areas. Note elimination of cut and fill on Rt. 2, for instance, or deletion of Rt. 124 and its fording site data, etc. From an examination of aerial photos the LOC analyst updated Rt. 123 south of Built-up Area. This example illustrates how, from the more detailed data base overlay (above), an analyst selects LOC-pertinent data.

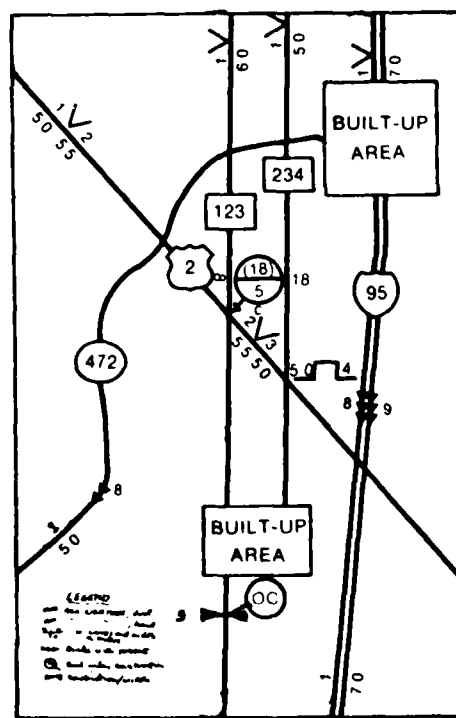


Figure 4. Comparison of Data Base Factor Overlay and Simplified Roads LOC Overlay.

By examining the legend and the accompanying Data Table for the MGI TGDB Roads and Related Structures factor overlay, the analyst selects the following essential route information to be shown on the LOC overlay:

1. Type

All-Weather, dual highway

All-Weather, hard surface

All-Weather, loose surface (if requested or if deemed pertinent by the analyst)

Fair Weather, loose surface (if requested or if deemed pertinent by the analyst)

Trail, Track (if requested or if deemed pertinent by the analyst)

2. Width                      Widths in meters

3. Constrictions            Widths in meters

4. Grade                      Only where the grade exceeds 7 percent

5. Sharp Curves              Only where the radius is less than 30 meters

6. Road or Bridge  
(under construction included)

One point to remember is that the above data are culled from a greatly detailed MGI TGDB factor overlay and attendant data tables. For LOC purposes, the detailed information usually presented in the Roads and Related Structures factor overlay far exceeds the information needed for an LOC study. However, if the analyst deems that the locations of road culverts, for example, are relevant to the LOC study, they can be selected from the data base overlay, if shown thereon, and shown in addition to the data elements above.

A second point to remember is that the data shown on the Roads and Related Structures factor overlay and in the accompanying Data Tables have been previously obtained by careful analysis of all relevant literature and aerial photography. For synthesis work, the analyst is essentially choosing from this comprehensive data only the Roads information necessary to meet a requirement for LOC.

## B. LOC Photo Analysis for Roads

Although the MGI TGDB factor overlay shows data derived in part from aerial photos, analysts engaged in LOC studies should obtain and examine relevant photography for their area(s) of interest. The principle reason for this is to correct for any manmade changes to the area road network since the completion of the MGI TGDB factor overlay and data table.

To assist terrain analysts who may have had limited experience in examining aerial photography (in terms of roads analysis), a checklist of photointerpretation tasks is provided in table 2 below.

Table 2. Roads checklist of photointerpretation tasks for an LOC product

1. Assemble photos.
2. Add pertinent roads not shown on the LOC overlay.
3. Measure widths of traveled way.
4. Determine road surface material.
5. Identify segments.
6. Verify grades over 7 percent.
7. Examine road junctions.
8. Locate and record constrictions/obstructions.
9. Verify construction activities.
10. Locate alternate routes and bypasses.

A short description of each task follows:

1. Assemble photos. An informal layup rather than a controlled mosaic should be adequate.
2. Add pertinent roads not shown on the LOC overlay. Depending on the date of the MGI TGDB preparation, additional roads in the category selected for the LOC study may have been constructed or older roads altered.
3. Measure widths of traveled way. For military purposes, it is sufficient to classify roads into width categories, although accurate measurements must be made at bottlenecks and the like. Very careful

measurements and a careful determination of what constitutes the carriage-way proper are also essential. External factors to be considered as influencing interpretation are halation if the light is bright, dust in dry weather, and shadows of trees and bushes.

4. Determine road surface material. The most important factor in road analysis is determining the surface material. The material may be concrete, blacktop, gravel, or earth depending on the importance of the highway (See ETL 0205 for help in this analysis.)

5. Identify segments. Usually a segment reflects a change in the road, either in surface material or width. Less commonly, a change in gradient or curves are used to identify segments.

6. Verify grades over 7 percent. A large scale topo map expedites the measurement.

7. Examine road junctions. Air photos readily give complete information of large road junctions. Give particular attention to the right angles at corners and the smoothness of the crossing. State the radius of acute-angled bends. With through or trunk roads, it is important to distinguish between those side roads that connect with the through routes and those that cross over or under.

8. Locate and record constriction/obstructions.

Sharp corners. Knowledge of the width of roads around sharp corners, particularly if the road is along the side of a steep mountain, is needed if traffic is to be maintained smoothly.

Bottlenecks. Note bomb craters, roadblocks, landslides, and narrowing of the roads. Some permanent bottlenecks are overhanging and protruding buildings, natural gorges, and bridges that have not been developed with the general widening of the road.

Road/rail intersections. Railways may pass over or under a road by bridges or by level crossing. Locate different levels and tunnels.

Industrial areas. In industrial areas, various forms of obstruction may be encountered. Overhead cable railways and cradles protecting the road may be mistaken for bridges. Pipelines or overhead conveyors between buildings are obstructions that may give less clearance to traffic passing underneath.

9. Verify construction activities. This activity is highly evident and easily identified.

10. Locate alternate routes and bypasses. In many countries, bridges are constructed with a maximum load capacity too low to permit



crossing of heavy vehicles. Therefore, it is essential to know if alternate routes are present, and once again air photos furnish additional and more recent information about the condition and suitability of these roads. Gradients and amount of engineering effort can also be ascertained from the photographs.

When performing the photointerpretation tasks outlined above, the analyst should keep in mind factors such as halation, associated terrain, and wetness that may cause erroneous interpretation. These factors are discussed below:

1. Halation. This is a diffused reflection from a light-toned surface against a darker background. It can cause a different appearance of the same road on different photographs. Roads may appear wider; the edges become obscure. However, underdeveloped or underexposed prints may reduce the effect of halation.

2. Associated terrain. For example, a broad, light-toned, unmetaled (dirt) track in sandy country may develop wavy edges caused by traffic spreading soft sand onto the firmer edges. Also, an unmetaled track on firm soil may appear to have the straight edges of a metaled road because it is firm enough to carry the normal flow of slow and relatively light farm traffic. A straight, broad road over a hill is sometimes broad because the traffic has encroached the edges of a poorly surfaced steep road. The narrower, more winding route following the contour may seem to be the better road to an analyst.

3. Wetness. Information as to whether a road has been photographed under wet or dry conditions is invaluable to the terrain analyst. Wetness can cause complete reversal of shade on a single print where one section of a road is wet and another dry. Metaled roads that have small puddles are likely to show patchy shades. Unmetaled and rough roads that are dry and photographed in bright light may appear smooth and white.

Appendix D lists references that assist in the detailed interpretation of aerial photography.

Because the amount of Roads data for LOC purposes is commonly much less than that shown on the MGI TGDB, the analyst can show by annotated symbols all the relevant information within the area of the LOC overlay. This eliminates the need for separate LOC Data Tables for Roads.

#### C. LOC Synthesis Procedures for Bridges and Overpasses

Examination of the MGI TGDB for Roads and Related Structures factor overlay(s) and accompanying Data Tables will provide LOC data elements for all bridges or overpasses in the area of interest. After becoming familiar with the road network to ascertain the locations of area bridges and overpasses, the analyst lightly pencils the pertinent data,

including roads, onto the LOC overlay. In general, the source overlay is the Roads and Related Structures factor overlay. If, however, the LOC request is for "Bridges/Overpasses only," the analyst excludes all roads in his tracing.

The comprehensive data base material will show all bridge and overpasses in the map area. For synthesis, however, the analyst selects only those Bridge/Overpass data he deems pertinent to the requested LOC study. An example is shown in figure 5.

Once the roads have been selected within the area of interest, all bridges or overpasses found on these roads are theoretically relevant to the LOC study. In some parts of the world, however, the number of bridges and overpasses per kilometer is so dense that analysts sometimes face a difficult decision. Which bridges or overpasses can be eliminated? How should the remaining structures be depicted on the LOC overlay so as to eliminate the need for separate Bridge/Overpass Data Tables?

For LOC purposes, bridges or overpasses equal to or in excess of 18 meters in length must be shown, as this distance is the limit of current Army Armored Vehicle Launched Bridging (AVLB) equipment. After examining the Bridges Data Table for all structures identified as less than 18 meters in length, the analyst ought to "lift" only those data elements referenced by asterisk below:

#### BRIDGES & OVERPASSES

- \*Length
- \*Width
- \*Load Class
- Construction Type
- \*Clearances
- \*Bypass Potential

To handle cases where the Bridge/Overpass data per map sheet is very numerous, the terrain analyst must use an abbreviated symbol (Appendix A). A unique number is then assigned each structure; the number refers to a particular structure described in a Bridge LOC Data Table that accompanies the study.

If, however, the number of Bridges/Overpasses is such that the data can be presented by symbols within the area of the map, this should be the preferred method. Bridge Tables that are physically separate from the LOC study are easily lost in the field environment.

After examining the Bridges Data Table, the analyst selects the following Bridges/Overpasses data elements for structures in the LOC study area:



1. Overhead clearance in meters.
2. Military Load Classification for one-way wheeled traffic or capacity in metric tons.
3. Width of the roadway in meters.
4. Bypass potential within 1 km of the structure.

D. LOC Photo Analysis for Bridges/Overpasses

Updating Bridge/Overpass data found in the MGI data base is sometimes necessary. Terrain analysts can assist in this task by obtaining and examining aerial photos that cover the roads in their LOC study area. Table 3 below outlines the steps required to analyze aerial photos for their Bridges/Overpasses content. The data derived from the analysis is penciled by symbol onto the LOC overlay; if data are too numerous, the analyst must construct an abbreviated Bridge/Overpass Data Table using the data elements mentioned previously.

Table 3. Checklist of photointerpretation Tasks  
for LOC - Bridges/Overpasses

1. Locate bridges/overpasses.
2. Select vertical and oblique photos of bridges/overpasses.
3. Determine bridge/overpass characteristics.
4. Evaluate bridge/overpass bypass conditions.

In Appendix D, references are listed that can assist analytical interpretation of aerial photos for their LOC Bridge/Overpass content.

A short description of each task follows:

1. Locate bridges/overpasses. Bridges, because of their pattern of structure, are easily identified on aerial photographs. Their shadows are the most revealing of all factors used in photo analysis by terrain analysts. If the bridge, at the moment of exposure, is directly below the camera, examination of the shadow will be the only way of definitely establishing the shape of the supports and number of spans. Frequently, shadows give the only indication as to the points from which measurements can be taken. The absence of shadows, of course, limits information on the overall dimensions and general characteristics of bridges.

2. Select vertical and oblique photos of bridges/overpasses. By providing a side view of the structure, the analyst can use oblique photos as the best source to determine the type of construction, material, length, overhead and underbridge clearances, number and type of spans, and length of individual spans. Measurement is dependent on accurate determination of the scale, which must be done carefully. Where practical, duplicate measurements should be made on vertical photography and the results averaged.

Although measurements on vertical photos are usually more accurate than similar measurements made on oblique photos, the vertical photos do not provide the side view so useful in determining the type of construction. Where there is a definite shadow of the bridge, it will often provide much of the same information available from oblique coverage. When there is no shadow of the bridge, examine the surrounding verticals and look for an image of the bridge that falls near the edge of the photograph. Images near the edge of vertical photos are often displaced or tilted so that the side of the object is visible.

3. Determine bridge/overpass characteristics. Determining the military load class cannot be done directly from aerial photography, but can be roughly estimated from vehicles that were using the bridge at the time the photography was taken. Examine the photos and identify any vehicles that may appear on the bridge. If the load class of the vehicle can be estimated, it can be assumed that the class of the bridge is at least the same. If no vehicles are actually on the bridge, examine the vehicles that have already crossed or are approaching the bridge. On large scale (1:2,000 to 1:15,000) aerial photography, panchromatic, color, etc., structure construction type and materials such as masonry, wood, steel-reinforced concrete, and steel are easily identified by indicators that appear on the photograph. These indicators include photographic tone/color, texture, and careful study of the structure shadow. With detailed study of the photographs, especially under stereo conditions, the analyst should be able to determine not only the type of construction but also the major type of material composing the structure (see ETL 0205, Table 6, for aid in obtaining this data).

4. Evaluate bridge/overpass bypass conditions. To determine bridge/overpass bypass conditions from aerial photography, study the area adjacent to the structure under stereo conditions and note any indications of shallow water, which can be identified, for example, by sandbars or rocks that are visible through the water surface. In addition, look for vehicle tracks along the river bank that indicate the location of an existing ford. When the structure is a dam used as a bridge, examine the downstream side of the dam. On the downstream side, the water is often shallow enough to be used as a bypass, and because dams are almost always sited where bedrock is close to the surface, the stream bottom conditions are usually firm enough to support most types of vehicles.

#### E. LOC Synthesis Procedures for Fording Sites

Except locally, and in certain parts of the world, the number of fording sites of significance to military operations is probably small. The terrain analyst, however, is responsible for locating all known fording sites within his map area.

The MGI TGDB Roads and Related Structures factor overlay will, if properly prepared, show known fording sites across the main streams and, in some instances, across secondary streams. If the crossings are deemed critical because of adjacent rugged terrain that precludes, for instance, bypassing of a blown bridge, or because of other reasons, the LOC product must be accompanied by a completed Fording Site Data Table. (For a detailed treatment of the data collected in analyzing fording sites see ETL 0205.) In most instances it is sufficient for the analyst to locate a known fording site (by symbol, FORD) on the LOC base overlay.

#### F. LOC Photo Analysis for Fording Sites

If photography is available, the quality of the synthesis effort is greatly enhanced. Quite possibly, the terrain analyst may occasionally need to revise or update the data base materials. Accordingly, a checklist of photointerpretation tasks is provided in table 4.

Table 4. Checklist of photointerpretation tasks for LOC for Fording Sites

1. Determine watercourse depth.
2. Measure ford length/width.
3. Determine watercourse velocity.
4. Locate entrances and exits.
5. Examine ford for obstacles.
6. Analyze approaches.
7. Determine bottom characteristics.
8. Compare ford characteristics with vehicle and pedestrian crossing capabilities.
9. Note climatic conditions.

A short description of each task follows:

1. Determine watercourse depth.

Depth can only be determined in very general terms from air photographs. If a waterway is shallow, there is likely to be turbulence or rippling at the surface. The bottom may also be visible. Deeper waters are likely to have a smooth surface and a dark appearance.

A sluggish stream or river may become a torrent in a few hours, or even minutes, as a result of sudden heavy rainfall. This is particularly true in tropical and arid regions. Additional factors that require consideration are upstream locks or dams, which may cause floods when opened or destroyed, thus temporarily disrupting crossing.

2. Measure ford length/width. Use normal measuring procedures.

3. Determine watercourse velocity. There is no accurate method for determining stream velocity from aerial photography. When determined from other source materials, the velocity of the current and the presence of debris are recorded to determine the effect, if any, on the condition and passability of the ford. Current is estimated as swift (more than 1.5 meters per second); moderate (1 to 1.5 meters per second); and slow (less than 1 meter per second). (To convert knots to meters/second, multiply by 0.5145.)

4. Locate entrances and exits. Gentle sloping entrances and exits are desirable for fording and swimming operations. Slope is expressed in percent. It must be remembered that a vehicle's capability is significantly reduced in climbing wet, icy, or rutted banks.

5. Examine fords for obstacles. An obstacle to river crossing operations includes high banks.

6. Analyze approaches.

Approaches may be paved with concrete or a bituminous surface material, or covered with mat or trackway, but are usually unimproved. The composition and the slope of the ford approaches should be carefully noted to determine its trafficability in inclement weather and after fording vehicles have saturated the surface material. Some fords have the sides of the roadway marked by boulders that appear on the imagery.

Where the ford has been raised by adding material to the bottom of the stream, the sides may appear as lines of ripples or eddies of a lighter tone than the surrounding water.

7. Determine bottom characteristics.

The composition of the stream bottom of a ford determines its trafficability. It is important, therefore, to determine if the bottom is composed of sand, gravel, silt, clay, or rock; this can usually be inferred from the surrounding terrain. In some cases, the natural river bottom of a ford may have been improved to increase load-bearing capacity and to reduce the water depth. Improved fords may have gravel or concrete surfacing layers of sandbags, metal screening or matting, timber (corduroy) or wooden planking. During high water periods, low water bridges may be easily confused with paved fords as both are completely submerged. It is important to differentiate between this type of bridge and a paved ford because of corresponding military load limitations.

Ford bottom characteristics. The ability to identify a paved, rocky, or sandy bottom solely from aerial photography depends on water depth, water clarity, film type, and photo scale. The analyst should attempt to determine this data element by the following steps:

1. Orient aerial photos of the ford for stereo viewing.
2. Study the area around the ford and the river or stream channel both upstream and downstream of the ford.
3. Look for indications that the road surface is continued across the channel. Evidence of the sub-surface road would appear as two faint lines that mark the width of the road surface or traveled way.
4. Rapids, white water, and exposed rocks or boulders indicate a rocky bottom. Bars, braiding, and steep banks will often indicate coarse-grained material, such as sand or gravel. Meanders and oxbows in the immediate vicinity indicate relatively slow moving streams with fine-grained material. Angular drainage patterns with frequent sharp changes in direction indicate rock control and probably a rocky bottom. In swift-flowing streams in mountainous areas, the fine materials do not settle; therefore, the bottoms are usually rocky or firm.
8. Compare ford characteristics with vehicle and pedestrian crossing capabilities. Fords are classified according to their crossing potential for pedestrians or vehicles (figure 6).



Type of Traffic	Shallow Fordable Depth (Meters)	Minimum Width (Meters)	Max Percent of Slope for Approaches <sup>1</sup>
Foot	1 (39")	1 (39") (single file)	100%
		2 (79") (column of 3's)	
Trucks and truck-drawn artillery	.75 (30")	3.6 (12')	33%
Light tank	1 (39")	4.2 (14')	50%
Medium tank <sup>2</sup>	1.05 (42")	4.2 (14')	50%

<sup>1</sup> Based on hard, dry surface.

<sup>2</sup> Depths up to 4.3 meters can be negotiated with deep water fording kit.

Figure 6. Fording Site Trafficability Data

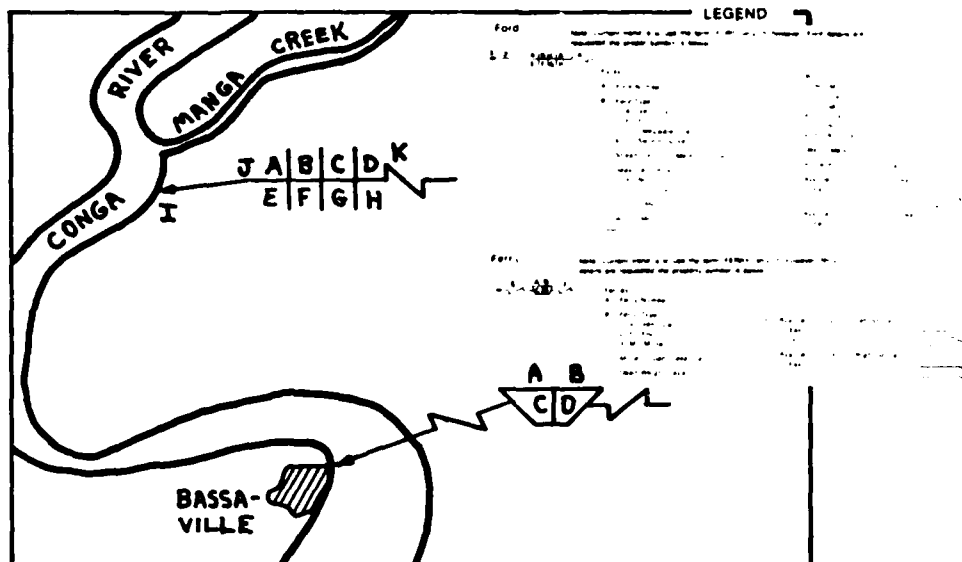
9. Note climatic conditions. Seasonal floods, dry seasons, freezing, and other extremes of weather materially affect the fordability of a stream (see figure 7). In Appendix D references are listed that aid the interpretation of aerial photos for their LOC Fording Sites content.

#### G. LOC Synthesis Procedures for Ferry Sites

Many of the terrain features common to Fording Sites (see above) are also significant to Ferry Sites. For military planning purposes, both are considered as obstructions and are recognized as such in the road classification formula.

Ferry Sites, at which traffic and cargo are conveyed across a stream or body of water by a floating platform, vary greatly in physical appearance and usage. The traffic being ferried, water depth, and velocity are factors influencing Ferry Site locations and characteristics. Pedestrian ferries are commonly not shown unless they are the sole means of crossing in an area.

Upon examining the data base materials, the analyst can obtain most of the LOC-relevant data element information as shown on the following page. Pencil lightly the data onto the base LOC overlay.



NOTE: In the above drawing, the symbols and data are shown for both Lording Sites and Ferry Sites. For most LOC studies, unless the request specifies a need for detail, the simplified symbols shown below will suffice.

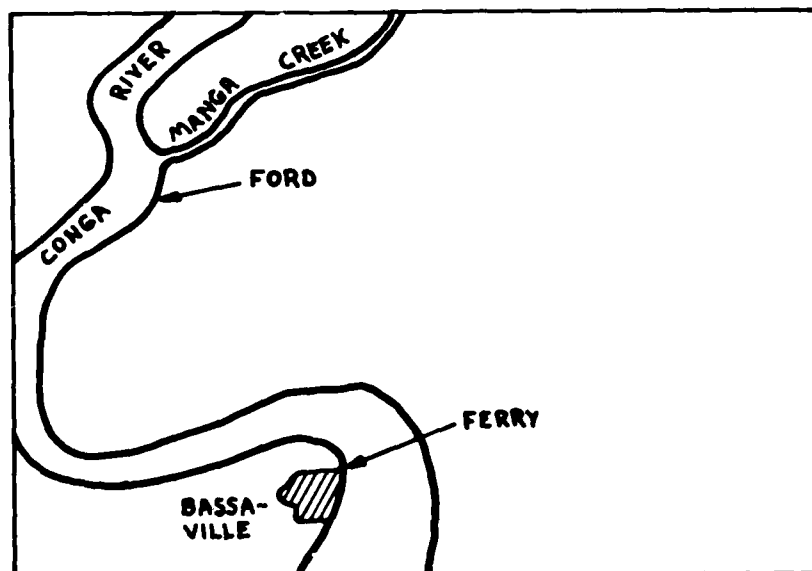


Figure 7. Comparison of Standard Fording and Ferry Site Symbols with Simplified LOC Usage.

## FERRIES

Crossing Length  
Vessel Characteristics  
Approaches  
Load Class

### H. LOC Photo Synthesis for Ferry Sites

Terrain analysts in preparing LOC overlays may be required to locate previously unreported sites suitable for military rafting and/or ferrying operations. The information that follows will assist the analyst.

Equipment presently available for ferrying operations are either components of military pontoon bridges, which are assembled into rafts at the water's edge, or units of the mobile assault bridge (MAB), which consist of individual self-propelled amphibious vehicles assembled into a ferry when in the water. The following site characteristics are desirable for satisfactory military operations:

1. Current velocity between 0 and 1.6 meters per second. Not determinable by photo analysis.
2. Banks that permit loading without a great deal of preparation. Stable soil or soil/rock banks with low relief and little or no vegetation are easily recognized.
3. Approaches that permit easy access and egress. Sandy or stoney approaches; usually on the inside of stream meanders, are easily discerned.
4. Strong natural holdfasts. Bold rock outcrops or natural harbor are easily recognized.
5. No shoals, sandbars, or snags. Depending on seasonal riverine fluctuations or on tidal changes, this can be observed.
6. Sites clear of obstacles immediately downstream. Not always observable in photos.
7. Sites clear of mines and boobytraps. Not easily observed unless photo scale is sufficiently large.
8. Sufficient depth to prevent grounding at any point. Difficult to estimate.
9. Holding areas for vehicles awaiting passage. Usually observable in photos.

In the normal LOC routine, synthesizing terrain factors can occasionally require updating of data base materials (see ETL 0205 for a detailed treatment of the ferry site parameters involved in analysis).

For LOC purposes, ferry sites can generally be portrayed by the single word, Ferry, on the base overlay (figure 7 illustrates this).

In Appendix D references are listed that can aid in interpreting aerial photographs for their ferry site information content.

#### I. LOC Synthesis Procedures for Tunnels, Galleries, Snowsheds

Manmade passages through mountains are termed "tunnels." In mountain areas subject to local soil and rock slides, structures called galleries are built to protect roads or railroads. Where snow avalanches have historically occurred, protective structures are termed snowsheds; these are usually located at the higher elevations.

In the event of the terrain analyst having to update the MGI TGDB roads factor overlay or, as is more likely, having to verify critical tunnel parameters, a brief review of the air photointerpretation methodology is presented below.

#### J. LOC Photo Analysis for Tunnels, Galleries, Snowsheds

In general, galleries and snowsheds are built in mountainous areas and their similarity of design can make identification (from photos) difficult. Snowsheds are often located at the higher elevations, however, because the potential for snow avalanches prevails over that for rock and soil slides.

Careful study of the steepest slopes along all major mountain routes is an imperative in proper terrain analysis, particularly if the data will be used in LOC studies. Ancient slide scars can be recognized where bedrock is seen. The irregularity of vegetation patterns can suggest unstable slope conditions. Enormous isolated boulders often indicate past slippage.

In the absence of engineering literature for a given structure, neither map nor photo analysis is completely satisfactory. At best, photos complement map evaluation of these structures in mountainous terrain.

Use the checklist of photointerpretation tasks provided in table 5 to revise or update the data base materials. See Appendix D for references to aid in the photo update.

Table 5. Checklist of Photointerpretation Tasks for  
LOC - Tunnels, Galleries, and Snowsheds

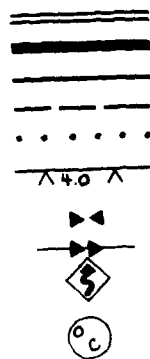
1. Assemble photos.
2. Determine structure function.
3. Verify length of structure.
4. Determine depth of overburden (tunnel).
5. Determine roadway width and clearances.
6. Evaluate structure bypass conditions.
7. Describe terrain adjacent to site.

A short description of each task follows:

1. Assemble photos. An informal layup will suffice to locate the area(s) known to have these structures.
2. Determine structure function, that is, tunnel, gallery, or snowshed.
3. Verify length of structure. Use normal measuring procedures.
4. Determine depth of overburden. Use normal measuring procedures. A large scale topo map expedites this effort.
5. Determine roadway width and clearances. Use normal measuring procedures.
6. Evaluate structure bypass condition. Usually at higher elevations, bypass for vehicular traffic is impossible. Foot traffic can generally bypass these structures, but at a considerable loss in time.
7. Describe terrain adjacent to site. Those factors that might affect movement, slope stability, seasonal aspects, or cover/concealment potential should be observable in photos.

# Appendix A Proposed Simplified LOC Symbols

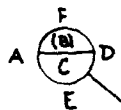
## Roads



- All weather, dual highway
- All weather, hard surface
- All weather, loose surface
- Fair weather, loose surface
- Trail, track
- Width in meters (Δ denotes traveled way width change)
- Constriction (width in m.)
- Grade > 7%
- Sharp curve (radius < 30m.)

Road or bridge under construction

## Bridge/Overpass (≥18 m in length)



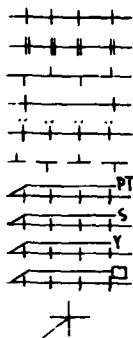
- A. Overhead clearance (m)
- B. Military load classification for one-way wheeled traffic or capacity in metric tons (in parenthesis)
- C. Width of roadway (m)
- D. Overall length (m)
- E. Bypass potential with one km.
  - a. easy
  - b. difficult
  - c. impossible

## F. Bridge Data Table

Where numerous bridges/overpasses exist, to reduce map clutter assign bridge no. and provide bridge data tables.

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## Railroads



Single track, standard gauge (4'8½")  
Multiple track, standard gauge  
Narrow gauge  
Broad gauge  
Electrified line  
Abandoned line  
Passing track  
Siding track  
Yard (length in m.)  
Railroad Bridge (≥18m) and overhead clearance  
Level railroad crossings

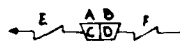
## Tunnels, Galleries, Snowsheds



A. Width clearance (m)  
B. Height clearance (m)  
C. Length (m)

## Ferry

Note: Current trend is to use the term, FERRY, only. If, however, ferry details are requested the proper symbol is below.



### Ferries

A. Ferry Number

B. Ferry Type

1. V - Vehicular
2. F - Foot
3. M - Military

C. Military Load Classification

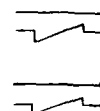
D. Dead Weight Capacity

E. Approach Condition, Left Shore

1. Easy
2. Difficult

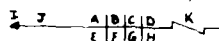
F. Approach Condition, Right Shore

1. Easy
2. Difficult



## Ford

Note: Current trend is to use the term, FORD only. If, however, Ford details are requested the proper symbol is below.



### Fords

A. Ford Number

B. Ford Type

1. A - Vehicular
2. P - Foot
3. D - Deepwater Tank
4. S - Swimming Vehicles

C. Stream Velocity (Meters Per Second)

D. Seasonal Limitations

1. X - None
2. Y - Significant

E. Length (Meters)

F. Width (Meters)

G. Bottom Type

1. M - Mud
2. C - Clay
3. S - Sand
4. G - Gravel
5. R - Rock
6. P - Artificial

H. Depth (Meters)

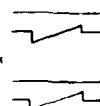
I. Arrow Points to Ford Location

J. Approach Conditions, Left Bank

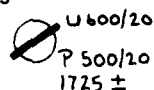
1. Easy
2. Difficult

K. Approach Conditions, Right Bank

1. Easy
2. Difficult



## Airfields



P = paved

U = unpaved

Show elevation

Length and width\* in meters

Line shows orientation of runway(s)

\*If not known, "U" shows unimproved surface

## Appendix B

### Airfield and Railroad Analysis Guidelines

This appendix provides terrain analysts objectives and design elements common to all factor overlays and generalized guidelines for the MGI analysis of maps, literature, and aerial photography for their Airfield and/or Railroad content. Upon completion of the analysis effort, the data is filed in the MGI Thematic Graphics Data Base (TGDB).

I. The following information provides objectives and design elements common to all factor overlays:

#### A. Objectives

The objectives of this section are to establish the operational concepts for the production of factor overlays and to prescribe the design and formats for those elements and components common to all factor overlays.

#### B. Operational Concepts

1. Factor overlays are intended primarily for use within the mapping and intelligence community, and in addition as quick reaction terrain products for distribution to the user.
2. Factor overlays provide formatted geographic data that can be readily retrieved and used in various combinations for terrain analysis and for production of special terrain products.
3. Factor overlays will be prepared in the form of stable base overlays that will accept photographic reduction to 70 by 105 mm and retain their legibility when enlarged back.
4. Normally each data field will require several factor overlays for each area. Data elements to be portrayed on each factor overlay, the symbology to be employed, and unique formats are specified separately for each data field.
5. These specifications do not treat methods of collecting or reducing data. Their purpose is to specify the manner of graphically recording collected and reduced data.

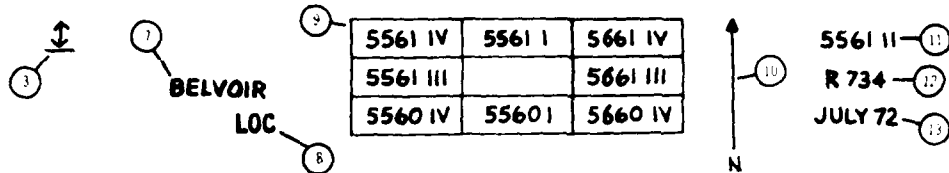
#### C. Format

1. General format specifications are indicated in figures B1 and B2.
2. No single factor overlay will exceed 660 by 860 mm (26 by 34 inches), including titles, legends, and other marginal data. Where use of



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1: 50,000  
USAETL



1. The map shall be drawn on stable paper of a size not less than 14 inches by 14 inches.

2. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

3. A scale bar of 2 inches shall be drawn at the top of the map, with the text '2 INCHES' written below it.

4. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

5. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

6. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

7. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

8. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

9. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

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16. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

17. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

18. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

19. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

20. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

21. The map shall be drawn on a grid of 100 squares, each with a 100-foot side.

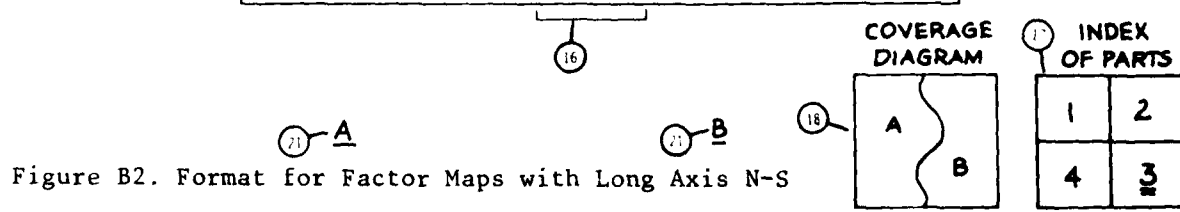


Figure B2. Format for Factor Maps with Long Axis N-S

a base map exceeding these dimensions is desired, the base will be subdivided and separate factor overlays prepared for each part. When an oversized base is subdivided, each subdivision will be assigned an identification and an index of parts prepared as per figures B1 and B2.

3. Whenever possible, factor overlays will be registered to a standard scale U.S. military map. Base maps other than U.S. military maps will be clearly identified in the upper right corner of the factor overlay.

4. Each factor overlay will be punch registered to the base map at two opposite sides of the neat line.

5. A neat line 0.5 mm wide will be placed on each factor overlay. This neat line will normally coincide with the neat line of the base map.

6. Legend information will be placed on the areas identified as A, B, C, and D on figures B1 and B2 in that sequence. Area A will be used first, B second, etc. Where the legend is too large to be accommodated in the areas provided, it will be placed on a second piece of overlay material. This legend overlay will be prepared in the same format as the factor overlay and will bear the same identification data.

#### D. Symbolization

Symbols are specified separately for each data field. However, the following general guidelines will be followed:

1. All lines will be at least 0.09 mm (0.004") wide with a minimum spacing of 0.18 mm (0.008") between lines. When adjacent linear features would overlap if symbolized in their true position, the least significant feature will be displaced to provide the 0.18 mm clearance.

2. All letters will be at least 3.2 mm (0.125") high (elite type-writer type).

3. All letters, numbers, and symbols will be positioned so as to be readable from the bottom or right side of the sheet.

4. All symbols, letters, and numbers will be drawn in black (plastic or mylar sheets) ink or black "Prisma" pencil.

5. Areas with a greatest dimension less than 2 mm will not be delineated. Areas with a greatest dimension less than 8 mm (.32") will be identified by lead lines.

6. Tick marks will be placed on the four outermost grid intersections so as to form a rectangle. Each leg of the tick marks will extend 3 mm from the intersection. These ticks are required to permit addition of the grid during the reproduction process.

II. The items listed below represent airfield and railroad data elements that terrain analysts should consider as being applicable to an LOC product. The data elements essential for an LOC product are identified with an asterisk.

#### AIRFIELDS

Identification  
 \*Runway orientation  
 Type  
 \*Surface Material  
 Parking Facilities  
 Hangars  
 POL  
 Ammo/Bomb Storage  
 Quarters  
 \*Elevation  
 \*Length/width

#### RAILROADS

\*Electrified  
 \*Abandoned  
 Routes  
 \*Yards/Terminals  
 Rolling Stock  
 Junctions/Crossings  
 \*Track(s)  
 \*Gage(s)  
 \*Bridges

The following paragraphs briefly describe map, literature, and photo analysis techniques for obtaining airfield and railroad terrain data:

#### A. Map Analysis for Airfields

Examining the map legend can be informative in obtaining data elements for airfields (airbases, airports, airstrips, etc.). The information can then be presented in graphic and in tabular form for use in LOC planning.

After becoming familiar with the airfield(s) on the map, the analyst should evaluate them in terms of the data elements below. These data are lightly penciled onto a base LOC mylar overlay.

#### AIRFIELDS

<u>Data Elements</u>	<u>Comments</u>
Location	Determine UTM or geographic coordinates.
Category	Configuration may suggest type if not described.
Elevation	-----
Layout	Runways, taxiways orientation.
Approaches	Length, width, glide, slope, obstacles.
Servicing	POL and ammo area(s) can be tentatively estimated by road or rail access.

If literature is available, the analyst can complete an Airfield Data Table (figure B3) to accompany the data derived from the map analysis.

Service-ability	Category	Location	Elevation (m)	Runways			POL storage	Ammo storage	Hangers*	Electrical Facilities
				Orientation	Length/Width (m)	Construction				

\*If significant, include taxiways, parking areas, aprons, hardstands

Figure B3. Airfields Data Table

#### B. Literature Analysis for Airfields

With literature, the terrain analyst can use table B1 (modified from FM 30-10) to help organize the information.

Table B1. Checklist For Airfields

1. Identification. Local name and military designation.
2. Location.
  - a. Map reference - series and sheet number(s).
  - b. UTM and geographic coordinates.

3. Airfield category. Liaison, surveillance, light lift, medium lift, tactical, or heavy lift.
4. Status.
5. Type.
6. Principal use.
7. Layout.
8. Elevation (meters).
9. Number of runways.
10. Each runway.
  - a. Identification.
  - b. Azimuth.
  - c. Length and width.
  - d. Surface, base, subbase course.
  - e. Longitudinal grade (minimum and maximum change per 100 feet).
  - f. Transverse grade (maximum).
  - g. Shoulders, clear area, and overrun.
  - h. Lateral safety zone.
  - i. End clear zones.
  - j. Approach zones.
  - k. Condition.
11. Each taxiway.
  - a. Identification.
  - b. Azimuth.
  - c. Length and width.
  - d. Grade.

- e. Surface, base, subbase material.
  - f. Bearing capacity (pounds per square inch).
  - g. Shoulders and clear area.
  - h. Turn radii.
  - i. Condition.
12. Parking and warm up aprons.
- a. Number.
  - b. Total area and individual area.
  - c. Description of each apron.
  - d. Total capacity.
13. Hardstands.
- a. Total number.
  - b. Aircraft capacity (specify).
  - c. Description of each hardstand.
14. Petroleum, oil, and lubricants.
- a. Jet fuel by type (J rating).
  - b. Aviation gasoline.
  - c. Jet oil.
  - d. Aviation oil.
  - e. Lubricants.
  - f. Pipelines.
15. Navigation facilities.
16. Lighting facilities.
17. Communication facilities.
18. Maintenance facilities.

19. Oxygen availability.
20. Special equipment.
  - a. Crash and fire.
  - b. Construction and ground maintenance.
21. Covered storage.
22. Sanitation.
23. Hangars.
  - a. Number and locations.
  - b. Type and material.
  - c. Condition.
24. Housing facilities.
25. Munition storage.
26. Administration buildings.
27. Electricity.
28. Jet starting units.
29. Auxilliary power units.
30. Anti detonation fluid/water-alcohol.
  - a. Type and location.
  - b. Quantities.
31. Defenses.
32. Adjacent terrain.
33. Medical facilities.
34. Weather facilities.

In most situations, terrain analysts will have aerial photography available that covers their geographic area(s) of interest. The section



that follows enables the analyst to use the photography to extract airfield data relevant to LOC overlay preparation.

### C. Photo Analysis for Airfields

Terms often used synonymously for airfield are those that apply to fields of various sizes and purposes, such as airbase, airdrome, airport, emergency landing sites, and auxiliary airfields.

The steps required to analyze aerial photos for their airfield content are given in table B2.

Table B2. Checklist of Photointerpretation  
Tasks for LOC - Airfields

1. Assemble photos sufficient to include critical glide slope/obstacle (mountainous sites) factors.
2. Determine if operational.
3. Determine unusual activity (if any).
4. Measure runways; determine orientation.
5. Determine runway surface materials.
6. Determine type of aircraft.
7. Determine aircraft dispersal pattern(s).
8. Determine types of structures.
9. Determine POL, ammo, bomb storage areas.
10. Determine alternate landing site potential.

The identification of runway surface types is an important factor in LOC airfield analysis. Given this information along with runway length, the analyst can estimate type of aircraft the runways are capable of supporting and determine the potential for sustained operations. In order to assist the analyst to determine surface types, representative runway surface signatures identifiable in aerial photos are on the following page.

<u>Type of Surface</u>	<u>Surface Outlook</u>	<u>Color</u>	<u>Other</u>
Sod	Irregular	Brown to green mottled (color photos)	Tire tracks
Graded Earth, Gravel, Sand Coral, Clay	May have grader marks	Light to dark color, mottled	Open pits in vicinity; (source of surfacing material)
Pierced metal plank	Grid pattern	Brown to green, mottled	Piles of Steel Plank in Area
Concrete	Smooth, surface may be patched or painted	Light grey to white, uniform	Block pattern
Asphalt	Smooth, surface may be patched or painted	Very dark to light grey, usually uniform	None

Figure B4. Photo Characteristics of Runway Surface Materials

References in appendix D facilitate the analytical evaluation of aerial photos for their LOC airfields content.

#### D. Map Analysis for Railroads

Railroads are the most important type of inland transportation in practically every country in the world. From an LOC standpoint, this importance is due to the direct logistic support afforded military operations. As a highly desirable adjunct to extended military operations, railroads are of primary concern to personnel at the highest level.

The present concept of warfare, with its emphasis on dispersal and the requirements for more and smaller rear installations, also lends importance to secondary and feeder lines.

Railroads naturally assume increased military importance in areas where the soils are generally untrafficable, roads are poor, and rail transportation facilities are extensive. Frequently railroads can be used as substitute roads for vehicles.

By careful map analysis, terrain analysts may obtain most of the data element information listed below. In general, however, railroad literature is needed to supplement the map analysis. The data are lightly

penciled onto the base LOC overlay (usually, the roads mylar) and, where sufficient information exists, a Railroad Data Table (Figure B5.) is completed to accompany the LOC overlay.

#### RAILROADS

##### Data Elements

##### Comments

Routes

Single-track (e.g. underground mines); multitrack (commonly labeled, e.g. two-tracked). Map legend very helpful. Bridges, tunnels, crossings are shown; culverts may need estimating.

Yards

Location (UTM or geographic coordinates); Configuration and Classification; Repair areas.

Critical areas

Rock cuts, slide - prone areas, tunnels, bridges.

Identity Function	Seg No	Segment UTM/GEOG Coord	Facilities				Track/Rail Electric	Rolling Stock	General Remarks
			Yards (type)	Freight	Terminal	Locomotive Repair			

Figure B5. Railroad Data Table

#### E. Literature Analysis for Railroads

The literature for railroads includes blueprints and drawings of station locations, main and secondary tracks, yard capacities, details on grades, railroad company operation rules, railroad standards, and operating timetables.

The table below is modified from FM 30-10 and is included to help analysts evaluate their source materials for railroads.

Table B3. Checklist for Railroads

1. Identification. Native, military, or other and segment being studied.
2. Location.
  - a. Map reference - Series and sheet number(s).
  - b. End points of segment - UTM and geographic coordinates.
3. Ownership.
4. Total track length. Double and single tracks in kilometers.
5. End points of double track sections.
6. Track.
  - a. Gage (millimeters)
  - b. Rails
  - c. Roadway (total width and double or single track).
7. Roadbed.
8. Sub-ballast.
9. Ballast.
10. Spacing of tracks.
11. Ties.
12. Radius of tightest curve.
13. Maximum grade.

14. Bridges.
15. Ferries.
16. Tunnels, Galleries, and Snow Sheds.
17. Underpasses.
18. Minimum clearances.
19. Axle load limit.
20. Culverts.
21. Electrification:
  - a. End points of electrified sections (UTM).
  - b. Power feed (overhead or third rail).
  - c. Current characteristics (AC or DC).
  - d. Source of power.
22. Mainline junctions:
23. Crossovers.
24. Passing sidings.
25. Stations:
  - a. Location.
  - b. Function.
  - c. Facilities.
26. Freight handling facilities.
27. Yards.
28. Repair shops/locomotive terminals.
29. Fuel facilities.
30. Watering facilities.
31. Signals and train control.

32. Critical points:

- a. Type (points subject to rock slides, snow slides, flooding, or subject to interdiction and ambush).
- b. Location.

33. Use: Average number of trains per day.

34. Sections in need of repair.

35. Construction, maintenance, and repair equipment.

36. Maintenance schedule.

37. Planned extension and improvements.

38. Maintenance and construction standards.

39. Safety and security features.

40. Rolling stock.

F. Photo Analysis for Railroads

By careful photo analysis, the terrain analyst can greatly improve the railroads input to LOC studies, especially providing details of yards and terminals and rolling stock.

Analysts need to know about regional and national variations in railroad gages. (The gage of a railroad is the distance between the inner sides of the rails on a running track.) Throughout Canada, USA, and in most of Europe, the standard gage is 1.44 meters. A gage of 1.52 meters or wider, however, is found in USSR, Iceland, Finland, and Spain. A narrow gage of 1 meter is found frequently throughout Latin America. Using narrow gage is usually limited to mountainous areas, industrial areas, mines, logging areas, supply dumps, and coastal defense areas. Many of the countries that were using narrow gage rail lines are now adopting the standard gage of 1.44 meters because of their imports of US-made rolling stock.

The steps required to analyze aerial photos for their railroads content are listed in table B4. The data derived from the analysis is penciled onto the base LOC overlay and/or onto the Railroads Data Table (figure B5).

Table B4. Checklist of Photointerpretation  
Tasks for LOC - Railroads

1. Assemble railroad coverage.
2. Determine route components: roadbed, rails, ties, gage, bridges, tunnels, crossings, galleries, snowsheds.
3. Determine yard types: marshalling, freight.
4. Determine terminal types: passenger, freight (including transfer and/or storage).
5. Determine electrical system (if applicable).
6. Determine rolling stock: locomotives, passenger cars, freight cars, military stock, service/utility stock.
7. Determine miscellaneous facilities.

References in Appendix D can significantly assist terrain analysts in their evaluation of the LOC railroads content of aerial photography.

## Appendix C

### Foreign Maps

The symbology used in producing FRG and USSR maps is presented in tables C1 and C2, respectively. These maps, when available for your area of interest, can be used either as primary source material or to augment the data obtained from U.S. maps. Both of these countries produce military maps at scales of 1:50,000 and 1:25,000. The amount, detail, and accuracy of the information presented will, of course, vary with the scale and date of publication.

A study of the symbology in tables C1 and C2 reveals that these maps provide considerably more information for LOC-related elements than is presently available on U.S. map legends.

If 1:50,000-scale foreign maps are available for an area, they can be substituted directly for the U.S. maps, and with the help of either table C1 or C2, the analyst can produce the initial draft of the LOC map.

When maps of scales other than 1:50,000 are available, the analyst can either adjust the scales photographically or, more simply, record the information directly from the foreign map to the U.S. map overlay.



**TABLE C1. FEDERAL REPUBLIC OF GERMANY MAP SYMBOLS  
FOR LINES OF COMMUNICATION (1:50,000 SCALE)**

Zeichenerklärung		Legend	
<b>Verkehrsnetz</b>		<b>Communications</b>	
	Autobahn, Parkplatz im Bau		autobahn, parking area, under construction
	Autostraße, mit oder ohne Mittelstreifen		dual highway, with median or center line only
	Europa-Bundesstraßennummer		route number
	Fern-Bundes bzw. Hauptstraße 6 m oder breiter		trunk road, federal main road, main road, 6 m wide or more
	Nebenstraße 4.6 m		secondary road 4.6 m wide
	Fahrweg, befestigt		road, light surface
	Fahrweg, unbefestigt		road, loose surface
	Feld- und Waldweg		fair weather road, loose surface
	Fußweg, Pfad, Klettersteig, Wattenweg		footpath, climbing path, track across tidal flats
	Straßentunnel, Eisenbahntunnel		tunnel, road and railroad
<b>Topographische Einzelzeichen</b>		<b>Other Topographical Details</b>	
	Damm, Deich, befahrbar, nicht befahrbar		embankment, dike, practicable, impracticable (for traffic)
	Einschnitt, Bäume entlang von Straßen		cut, roads tree lined
<b>Brücken und Gewässer</b>		<b>Bridges and Hydrography</b>	
	Eisen-, Stein- oder Betonbrücke		iron-, stone- or concrete bridge
	Hebe- oder Drehbrücke		lift or swing bridge
	Holzbrücke		wooden bridge
	Steg		footbridge
	Eisenbahnfähre		train ferry
	Wagenfähre		vehicle ferry
	Personenfähre		passenger ferry
	Furt		ford
	Landungsbrücke		landing stage
	Talsperre		dam (across a valley)
<b>Grenzen</b>		<b>Boundaries</b>	
	Staatsgrenze		international boundary
	Landesgrenze		boundary between "Länder"
	Regierungsbezirksgrenze		boundary of "Regierungsbezirk"
	Kreisgrenze		boundary of "Kreis"
	Standort- und Truppenübungsplatzgrenze		boundary of training area
	Naturschutzgebietsgrenze		boundary of nature reserve

**TABLE C2. UNION OF SOVIET SOCIALIST REPUBLIC MAP SYMBOLS  
FOR LINES OF COMMUNICATION**

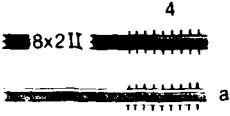
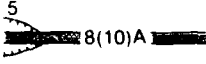
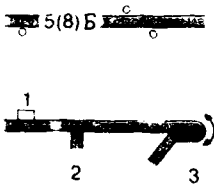
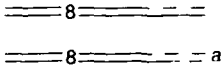


SYMBOL	FEATURE	DEFINITION
	Super Highway	<p>8 — Width of one lane in meters  2 — Number of lanes  (II) — TS. surfacing material, TS-cement-concrete.  (a) — (asphalt-concrete), Embankment — (4-Height of embankment in meters).</p>
	Improved Highways	<p>8 — Width of surfaced area (meters)  10 — Width of road from ditch to ditch (meters).  A-Surfacing material, A-Asphalt concrete, II — Cement-concrete, Бр — Block, Кн — Clinker,  Depressions — (5) Depth of depression (meters)</p>
	Highways	<p>5 — Width of surfaced part  8 — Width of entire road (meters)  Surface Material — Б, cobble stone; Г, Gravel, К, Crushed stone, Ш, Slag, (д) Plantings, М, Broken Stone.</p> <p>1. Small road side structures  2. Turn-offs  3. Rapid change in grade, small turning radius</p>
	Improved Dirt Roads	<p>8 — Width of road (meters)  Dashed line indicated a road that is difficult to negotiate.</p>
	Roads Under Construction	<p>1. Super Highways  2. Improved Highways  3. Highways  4. Improved dirt roads</p>
	Misc Highway Symbols	<p>1. Bridges across insignificant obstacles, culverts.  2. Road segments with steep grades 8 percent or more.</p>

TABLE C2 (cont)

SYMBOL	FEATURE	DEFINITION
	Winter Roads	
	Wooden surface Roads	
	Facined Sectors of Roads	
	Stone Walls	
	Change in Road Surface Material	
	Kilometer Post	
	Road Bridge Over Railroad	K: Stone 155-6: Length and Width (meters) 80: Load Capacity (tons)
	Railroad Bridge Over Highway	np: Passage Beneath 5: Vertical Clearance (meters) 9: Width (meters)
1:25,000 	Draw and Swing Bridges	
	Wooden	Single Symbol used at 1:50,000
	Metal	
	Masonry or Concrete	

TABLE C2 (cont)


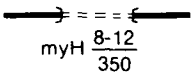
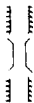
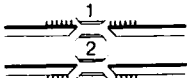
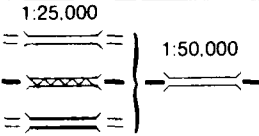
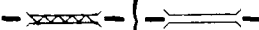
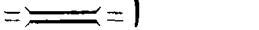
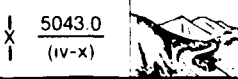




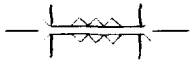
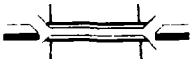
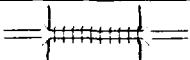
SYMBOL	FEATURE	DEFINITION
	Grade Crossing	
	Tunnel	8 — Vertical clearance meters 12 — Width 350 — Length
	Aquaduct	
	Double Decked Bridge	1: Highway under railroad 2: Highway above railroad
	Wood Bridge	Single Symbol used at 1:50,000
	Metal Bridge	
	Masonry or Concrete Bridge	
	Mountain Pass	5043.0 Elevation (meters)
	Dirt Roads	Also roads difficult to negotiate
	Field and Forest Roads	
	Pack Trails	
	Foot Path	

TABLE C2 (cont)

SYMBOL	FEATURE	DEFINITION
	Floating	
	Double Decked Masonry or Concrete	
	Chain and Rope	
K8 $\frac{370-10}{60}$	Bridge Characteristics	K: Material 370: Length (meters) 10: Width 60: Load Class 8: Under Clearance

## Appendix D

### Supplementary References

#### Remote Sensing

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- The definitive single source reference on all aspects of remote sensing.

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*Terrain Analysis*; 1978; FM 21-33; HQ, Department of the Army; Washington,  
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